

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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 B2J 1A



(54) APPARATUS AND METHOD FOR REMOVING SOLID PARTICLES AND/OR OTHER IMPURITIES FROM A GAS

(71) I, ALVIN MELVILLE MARKS, a citizen of the United States of America, of 153—16 10th Avenue, Whitestone, New York, United States of America, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention concerns an apparatus and method for removing solid particles and/or other impurities from a gas. More particularly this invention concerns the control neutralization, detoxification, and disposal of pollutants in gases resulting from combustion, such as 15 internal combustion engine exhaust gases, gas borne industrial and residential waste and the like.

20 The control of pollutants resulting from combustion has been particularly difficult because of the minute nature of many of the fume particles and the complexity of the products of combustion. Where the particles are of some size such as fly-ash or dust, filters and electrical precipitation have been employed with some effect. However, the smaller 25 particles pass through such devices into the air causing substantial contamination.

30 In the case of internal combustion engines there have been provided devices for passing the exhaust gases back through the engine in an effort to reduce atmospheric contamination.

35 Accordingly, the present invention aims to provide a device for removing pollutants from the gases of combustion.

40 The present invention also aims to provide a device which will reduce the harmfulness of the exhaust gases from internal combustion engines before said gases are discharged into the atmosphere.

45 The invention also aims to provide an apparatus, which is extremely simple in construction and operation, for removing solid particles and/or other impurities from a gas.

Still another aim of the present invention is to provide an inexpensive apparatus, which

will occupy only a small space, for removing solid particles and/or other impurities from a gas.

Another aim of the present invention is to provide an apparatus which is adapted for use on self-propelled vehicles, for removing solid particles and/or other impurities from the exhaust gas of the vehicle.

According to the invention there is provided an apparatus for removing solid particles and/or other impurities from a gas, comprising a conduit connectable to a source of gas containing solid particles and/or other impurities, a plurality of capillary tubes within the conduit, a source of liquid under pressure connected to one end of the capillary tubes whereby fine droplets of the liquid are sprayed from the other ends of the capillary tubes, a charging electrode spaced from said other end of the capillary tubes, a source of D.C. potential connected to the charging electrode for creating an electrical field between the charging electrode and the said other end of the capillary tubes whereby a spray of charged liquid droplets is formed, said charged liquid droplets entraining solid particles and/or other impurities when a gas containing solid particles and/or other impurities is passed into said conduit, and means downstream of the charging electrode for receiving and discharging the spray of charged liquid droplets whereby the droplets coagulate to form a disposable liquid containing the solid particles and/or other impurities entrained in said droplets.

The invention also provides a method for removing solid particles and/or other impurities from a gas, comprising the steps of passing the gas through a conduit having a plurality of liquid-containing and dispensing capillary tubes therein, passing the spray of liquid droplets dispensed by said capillary tubes through an electrical field including a charging electrode, whereby said liquid droplets become charged and solid particles and/or other impurities present in the gas become

entrained in the charged droplets, discharging the charged droplets, and allowing the discharged droplets to coagulate into a disposable liquid containing the solid particles and/or other impurities entrained by said droplets.

In the accompanying drawings there are illustrated three forms of embodiment of the invention, in which drawings similar reference characters designate corresponding parts, and in which:

Figure 1 is a somewhat diagrammatic view of a complete embodiment of the present invention with certain elements shown in block, and others in longitudinal section.

Figure 2 is a cross-sectional fragmentary view of the spray forming and droplet charging section of the present invention.

Figure 3 is a cross-sectional view taken on line 3—3, looking in the direction of the arrows.

Figure 4 is a fragmentary view greatly enlarged taken on line 4—4 in Figure 1, looking in the direction of the arrows.

Figure 5 is a view in longitudinal section of a portion of a second embodiment of the present invention.

Figure 6 is a view in longitudinal section of a portion of a third embodiment of the present invention.

Referring to the drawings, 10 indicates a conduit such as an automobile exhaust pipe, smoke stack, incinerator chimney or the like. The conduit 10 has an inlet end 11 and an outlet end 12, for the passage of the products of combustion to be treated. A suitable liquid such as water is led into the conduit 10 by means of a pipe 13 under pressure provided by a pump 14. The pipe 13 is connected to a reservoir 15 which contains the liquid and which, in the case of an automobile, may be the radiator of the vehicle. An array of capillary tubes 16 is disposed within the conduit 10, and is in communication with the liquid within the pipe 13. The capillary tubes 16 are similar in size to a small hypodermic needle and preferably have an internal diameter of 0.2 mm or less. The discharge end 17 of the array of capillary tubes is supported by a thin block 30 secured to the wall of the conduit 10.

A charging electrode 18 is disposed downstream of the ends of the capillary tubes 16, and spaced therefrom as shown in Figures 1 and 2. The electrode 18 which is in the form of a plurality of spaced vanes 19, is supported by an insulating plug 20 in the conduit 10. A D.C. voltage source 21 is connected to the charging electrode 18 by means of the lead 22. A D.C. voltage source of approximately 2,500 volts is suitable for the present invention. All of the elements in the system other than the charging electrode 18 are earthed.

By reason of the charging electrode 18 an

electric field is established between the electrodes 18 and the ends 17 of the capillary tubes 16. The liquid coming from the ends of the capillary tubes 16 is discharged into the conduit 10 in the form of a spray of minute charged liquid droplets 23. The droplets 23 have been marked with a plus sign to indicate a positive charge impressed thereon, but may be charged either positively or negatively.

The droplets 23 are combined with the products of combustion 24, moving through the conduit 10. As a result, solid particles carried by the products of combustion 24 are entrained by the charged droplets in the charging region between the capillary array 16 and the electrode 18. The liquid droplets in which the solid particles are entrained traverse the electrode 18 as indicated at 23' in Figure 1.

A collector screen 25 in the form of a lattice is disposed across the conduit 10 downstream of the electrode 18 as shown in Figure 1. The collector screen is made of electrically conductive material and provided with a plurality of needle-like points 26 which extend in the direction of the electrode 18 and serve to discharge the droplets 23. The discharged droplets 23 pass through the screen 25 and coalesce to form larger droplets 27 by the normal processes of coagulation within an uncharged spray of liquid. The larger droplets containing the solid particles therein emerge from the exit end 12 of the conduit 10 and may be collected or allowed to fall harmlessly to the ground as though they were rain drops.

If the apparatus of the invention is used with gases issuing from the exhaust of an internal combustion engine, it may be desirable to inject a small amount of hydrogen peroxide from a reservoir 28 into the pipe 13 so that it is mixed with the liquid therein. The peroxide will react with the carbon monoxide in the exhaust gases to form carbon dioxide and thereby eliminate the harmful carbon monoxide.

In order to compensate for variations in the amount of gases passing through the conduit 10 due to increases or decreases in the engine speed, the pump 14 should be connected directly to the engine in any suitable manner whereby increases in engine speed will increase the speed of the pump to force an increased amount of liquid into the conduit 10 so that a sufficient quantity of spray droplets is present within the conduit to entrain substantially all of the solid particles and other harmful products of combustion passing therethrough.

It has been found that only a small amount of liquid is necessary to produce a sufficient amount of charged droplets within the conduit 10 to entrain the harmful products of combustion. In addition, the power requirements, e.g. to produce the D.C. voltage, are

small, and the nature of the charging and discharging elements within the conduit 10 make for a very compact and inexpensive apparatus. Generally the mass of liquid passing through the conduit comprises .01% to 5% of the mass of gas passing through the conduit.

Referring to Figure 5, there is shown another form of apparatus made in accordance with the present invention in which the charged droplets 24, formed in the manner set forth in connection with Figures 1-4, and with solid particles of combustion entrained therein, are picked up by a collector electrode 32 in the form of a metal sleeve carried within the conduit 10 and separated therefrom by a dielectric layer 31. The collector electrode is maintained at a negative voltage if the droplets are positively charged and at a positive voltage if the droplets are negatively charged. As a result, the droplets are attracted to the collector electrode 32 and coalesce thereon to form a liquid film 27 which will flow out or be blown out of the exit end 12 of the conduit 10.

Referring to Figure 6 there is shown still another embodiment of the present invention in which the conduit 10 is forked as indicated at 28 to provide two passage-ways for products of combustion. A plurality of capillary tubes 16 connected to a pipe 13, similar to that shown in Figure 1, is disposed in one branch of the conduit 10. A second plurality of capillary tubes 16^a, connected to a second pipe 13^a, is disposed in the second branch of the conduit 10. A charging electrode 18 is disposed in the first branch spaced from the capillary tubes 16 and a second charging electrode 18^a is similarly located in the second branch. A positive D.C. voltage is applied to the charging electrode 18 and a negative D.C. voltage applied to the electrode 18^a. As a result, the charged droplets 23 and 23^a, that emerge from the electrodes 18, 18^a, respectively, are oppositely charged. When the droplets 23, 23^a, meet where the forked portion 28 of the conduit 10 ends, as indicated at 29, they coalesce and discharge each other, following which the discharged droplets further coalesce to form larger droplets 27 as described above in connection with Figure 1.

While the present invention has been described and illustrated with the conduit in the horizontal position as it might appear in an automobile exhaust, it is to be understood that the conduit might constitute a vertical chimney or vent. In the case of a vertical vent some suitable means (not shown) for leading the large droplets 27 out of the vent may be supplied, such means being well known within the art and forming no part of the present invention.

The present invention may also be used to detoxify or neutralize chemical wastes by mixing well known reactants with the liquid

used to form the spray. Thus, for example, fumes containing sulphuric acid or sulphurous acid can be reacted with sodium hydroxide dissolved in the charged droplets to render such fumes harmless. Alkaline fumes can be treated with hydrochloric acid dissolved in the charged droplets. Nitric Oxide NO. can be absorbed with a solution of alkaline sulphite or dithionate to give compounds of the type $M_2'SO_3 \cdot 2NO$.

WHAT WE CLAIM IS:—

1. An apparatus for removing solid particles and/or other impurities from a gas, comprising a conduit connectable to a source of gas containing solid particles and/or other impurities, a plurality of capillary tubes within the conduit, a source of liquid under pressure connected to one end of the capillary tubes whereby fine droplets of the liquid are sprayed from the other end of the capillary tubes, a charging electrode spaced from said other end of the capillary tubes, a source of D.C. potential connected to the charging electrode for creating an electrical field between the charging electrode and the said other end of the capillary tubes whereby a spray of charged liquid droplets is formed, said charged liquid droplets entraining solid particles and/or other impurities when a gas containing solid particles and/or other impurities is passed into said conduit, and means downstream of the charging electrode for receiving and discharging the spray of charged liquid droplets whereby the droplets coagulate to form a disposable liquid containing the solid particles and/or other impurities entrained in said droplets.

2. An apparatus according to Claim 1, in which the source of liquid includes a chemical capable of reacting with a toxic substance present in said gas source to produce a non-toxic or less toxic substance.

3. An apparatus according to Claim 2 in which said chemical is an oxidant whereby harmful oxidizable substances present in the gas may be detoxified.

4. An apparatus according to Claim 3 in which the oxidant is a peroxide.

5. An apparatus according to any preceding claim in which all of the components except the charging electrode are maintained at ground potential.

6. An apparatus according to any preceding claim in which the charging electrode is in the form of a plurality of spaced electrically conductive vanes past which the spray of droplets may flow.

7. An apparatus according to any preceding claim in which the discharge means is a collector electrode in the form of a lattice having a plurality of needle-like discharge points extending outwardly therefrom into the path of the spray of charged droplets.

8. An apparatus according to any one of

- Claims 1—6 in which the discharge means is a collector electrode in the form of an electrically conductive sleeve upon which there is impressed a charge opposite to that on the charged droplets. 40
- 5 9. An apparatus according to any one of claims 1—6, in which the conduit is forked to divide the gas into two streams, the capillary tubes are arranged as two sets and the charging electrode is replaced by two charging electrodes, one set of capillary tubes and one charging electrode being disposed in each fork of the conduit, means are provided to apply a positive D.C. voltage to one the electrodes and a negative D.C. voltage to the other electrode to produce two oppositely charged sprays of droplets, and the discharge means comprises a confluent portion of the conduit wherein the oppositely charged sprays of droplets meet and discharge each other. 45
- 10 10. A method for removing solid particles and/or other impurities from a gas, comprising the steps of passing the gas through a conduit having a plurality of liquid-containing and dispensing capillary tubes therein, passing the spray of liquid droplets dispensed by said capillary tubes through an electrical field including a charging electrode, whereby said liquid droplets become charged and solid particles and/or other impurities present in the gas become entrained in the charged droplets, discharging the charged droplets, and allowing the discharged droplets to coagulate into a disposable liquid containing the solid particles and/or other impurities entrained by said droplets. 50
- 15 11. A method according to Claim 10, including the step of adding an oxidant to the liquid before it is dispensed from the capillary tubes, whereby harmful oxidizable substances present in the gas may be detoxified. 55
- 20 12. A method according to claim 10 or 11 in which the charged droplets are discharged upon a sleeve of opposite charge from the charge droplets. 60
- 25 13. A method according to claim 10 or 11 in which the gas is directed into a conduit having first and second forks, a spray of positively charged droplets is formed in the first fork, a spray of negatively charged droplets is formed in the second fork and the charged droplets are discharged by combining the two sprays of droplets. 65
- 30 14. A method according to claim 10, 11, 12 or 13 in which the volume of the liquid passing through the conduit is varied in proportion to the volume of gas passing therethrough. 70
- 35 15. A method according to claim 10, 11, 12 or 13 in which the mass of liquid passing through the conduit comprises from .01% to 5% of the mass of the gas passing through the conduit.
16. An apparatus for removing solid particles and/or other impurities from a gas, substantially as herein described with reference to the accompanying drawings. 65
17. A method for removing solid particles and/or other impurities from a gas, substantially as herein described with reference to the accompanying drawings. 70

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FIG. 1

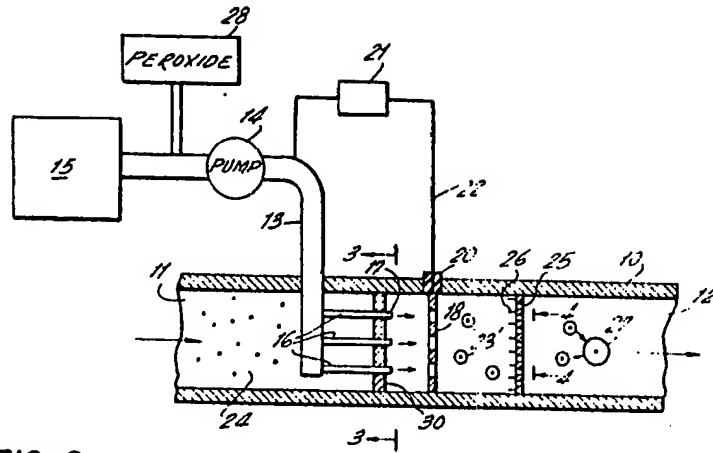


FIG. 2

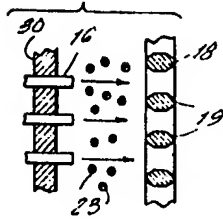


FIG. 3

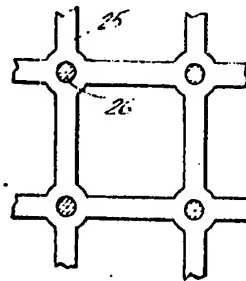
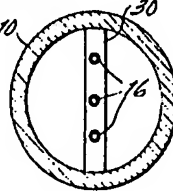


FIG. 4

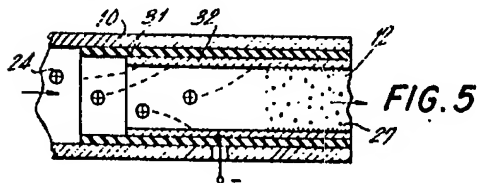


FIG. 5

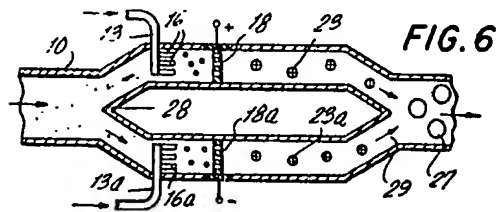


FIG. 6